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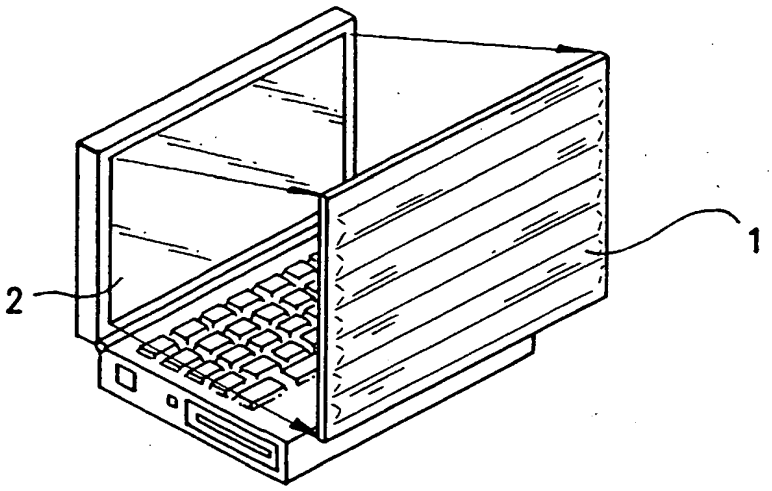
(54) Title: LCD SCREEN OVERLAY FOR INCREASING VIEWING ANGLE, IMPROVING IMAGE QUALITY, LINE DOUBLING, AND DE-POLARIZATION, AND STEREOSCOPIC SYSTEM UTILIZING SUCH AN OVERLAY



(57) Abstract: A lenticular or microprism sheet (1) having diffusion effects serves as an LCD (2) screen overlay for achieving an increased field-of-view or privacy screening as well as more uniform contrast of images displayed on the screen. The overlay may also serve as a line doubler and/or depolarizer, and is especially useful in stereoscopic systems that rely on polarization to distinguish between interlaced left and right images.

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LCD SCREEN OVERLAY FOR INCREASING VIEWING ANGLE, IMPROVING IMAGE QUALITY, LINE DOUBLING, AND DE-POLARIZATION, AND STEREOSCOPIC SYSTEM UTILIZING SUCH AN OVERLAY

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an overlay for a non-projection or direct-sight type of liquid crystal display (LCD).

The overlay is arranged to be positioned between the LCD and a viewer, and may be spaced apart from the display, or removably or permanently secured directly to and in contact with the display screen. The overlay consists of a lenticular or microprism sheet, defined as a sheet made up of a substrate and a plurality of lens or prism elements formed in the substrate, that has been modified to diffuse

light passing through the sheet. Uses of the overlay include increasing the angle of view of the display screen, providing privacy screening, smoothing differences in contrast across the field-of-view, reducing glare, line doubling, and de-polarization of light emitted by the display.

The invention also relates to an arrangement for de-polarizing light exiting the liquid crystal display, by using a lenticular or microprism sheet that has been modified to diffuse light passing through the sheet and thereby de-polarize the images displayed on the LCD, so that the display can be used as an image source in a stereoscopic effects system of the type disclosed in copending U.S. Patent Application Ser. Nos. 09/538,731, filed April 27, 2000 and 09/729,079, December 5, 2000.

The invention further relates to a line doubler made up of a plurality of cylindrical lenticular elements arranged on a grooved substrate or microprism sheet, or a lenticular sheet attached to or situated in proximity to a microprism sheet, and that is suitable for use in a variety of applications that might benefit from line doubling including, but not limited to, the above-mentioned LCD overlay and stereoscopic applications.

2. Description of Related Art

As indicated above, the present invention involves an overlay for a non-projection or direct-sight type of LCD. The direct sight LCD is an LCD that is intended to be viewed directly, such as the LCD screens commonly found on notebook computers, small televisions, and portable game players, and is to be distinguished from a projection-type LCD system of the type commonly included in projection televisions, in which images from an LCD are optically projected onto a display screen that is substantially larger than the LCD.

In particular, the invention concerns an overlay for a direct-sight LCD which has the advantages of increasing or modifying the angle at which an image on the screen can be viewed, reducing glare, and improving image quality by smoothing contrast and brightness variations, while also enabling line doubling and de-polarization.

It has been known since at least the 1980's that lenticular sheets could be used as, or in combination with, diffusers in the context of projection screens. In addition, lenticular or microprism sheets and diffusers have been used in connection with LCD backlights. However, despite numerous patents directed to projection screen or LCD backlighting arrangements utilizing lenticular or

microprism sheets, no patents issued with respect to use of lenticular or microprism sheets as direct view LCD overlays with diffusion properties, and it was not until 1996 that the first patent issued with respect to a non-diffusing direct view LCD screen overlay.

It may be that modification of lenticular or microprism sheets to serve as light-diffusing screen overlays for direct view LCDs simply did not occur to those skilled in the art, or that such overlays were thought to be un-necessary, impractical, or disadvantageous. Certainly, most of the technical problems associated with large screen projection systems, including image distortion and lack of brightness, do not apply to direct view systems, and thus direct view screen design has always been treated separately from projection screen design.

By way of background, among the patents that disclose use of lenticular or microprism sheets in projection systems are the following: U.S. Patent Nos. 4,730,897 (McKechnie *et al.*), 5,400,114 (Yoshida *et al.*), 5,457,572 (Ishii *et al.*), 5,581,407 (Mitani *et al.*), 5,760,955 (Goldenberg *et al.*), 6,002,829 (Winston *et al.*), 6,157,491 (Watanabe *et al.*), 6,025,897 (Weber *et al.*), and 6,169,633 (Watanabe), all of which are directed to rear projection screens that include lenticular and/or microprism sheets

which function as diffusers, or which are combined with diffusers. In contrast, only U.S. Patent Nos. 5,745,199 and 5,555,476, both to Suzuki *et al.*, disclose use of lenticular or microprism sheets in connection with a non-projection or direct sight type LCD systems, and each of these patents teaches a system in which diffusion is to be avoided.

The system disclosed in U.S. Patent No. 5,555,476, for example, seeks to increase the ratio of transmitted to reflected light by adding substrates having different indices of reflection to a one or two dimensional lenticular or "microlens" sheet made up of linear or discrete lenticular elements. This is contrary to the approach of the present invention, which is specifically to modify the lenticular sheet to diffuse transmitted light, and it is clear from the approach taken in this patent that the addition of a diffuser is not desirable.

The second of the direct view LCD screen overlay patents, U.S. Patent No. 5,745,199, is even more explicit in essentially teaching away from modification of a lenticular or microprism sheet to serve as a diffuser in the context of direct view LCD systems. In the system disclosed in this patent, a one or two dimensional lenticular sheet is provided with a diffusion axis oriented

to within 15° of the direction of the liquid crystal orientation of the liquid crystal cell. This arrangement precludes use of a diffuser, as explained in col. 5, lines 65 *et seq.* of U.S. Patent No. 5,745,199: "*of course, because a usual, so-called 'diffusion plate' or 'light scattering plate,' to which a light diffusion property is provided by a layer added with particles having a light diffusion property or by random concavities/convexities formed on the surface, scatter an entered ray randomly, such a plate cannot refract a ray in an appropriate controlled direction and it cannot be used in the present invention.*"

As a result, the only two patents disclosing the use of lenticular or microprism sheets in connection with a direct view LCD system teach away from modification of the sheets to exhibit diffusion properties, and at least one of those patents does so explicitly. Whereas the prior arrangement seek to exploit the inherent diffusion axis of a lenticular sheet, described in col. 6, lines 33-64 of U.S. Patent No. 5,745,199, the diffuser of the present invention actually counteracts the effect of the diffusion axis.

The result is an arrangement which might not have the optimal viewing angle of the system described in U.S.

Patent No. 5,745,199, but which has a number of other advantages, including a possibly less than optimal, but nevertheless useful increase in viewing angle, image smoothing effects, and the possibility of line doubling, and de-polarization. Moreover, these advantages are obtained by a very simple structure that can be built into the LCD, retrofitted, or provided as an inexpensive removable overlay that can be sold separately and added by the viewer to increase the viewing angle, achieve privacy screening, improve image quality, and/or achieve the effects of line doubling and de-polarization.

By adding diffusion properties to a lenticular or microprism sheet, the invention, in its broadest form, essentially converts the direct-view system into a rear-projection system, minus the magnification, and thus any advantages such as contrast balancing and glare reduction obtained by using a lenticular or microprism sheet and a diffuser in combination with a projection screen are also obtained in the context of a direct-view screen, and without the disadvantages of projection optics.

While the effects of light diffusing lenticular or microprism sheets on viewing angle and image quality have at least been noted in the context of projection systems, the possibility of using such sheets as a simple,

inexpensive line doubler does not appear to have been previously appreciated. The purpose of line doubling is to increase the apparent resolution of a display, which is especially useful in stereoscopic systems that simultaneously display left and right images, the left and right images each having half the lines of an undivided image.

Similarly, use of a lenticular or microprism sheet as a de-polarizing overlay for an LCD is unknown in the prior art. In fact, there appears to have been no need for any sort of LCD de-polarizer. For reasons to be explained below, it is only when the LCD is used as an image source in stereoscopic systems of the type disclosed in copending U.S. Patent Application Ser. Nos. 09/538,731 and 09/729,079.

Essentially, in the stereoscopic systems disclosed in copending U.S. Patent Application Ser. Nos. 09/538,731 and 09/729,079, the stereoscopic effect is obtained by polarizing and subsequent combining simultaneously-displayed left and right eye images. Since conventional LCDs require polarized light to operate, it should in theory be possible to achieve a stereoscopic effects device by using separate LCD screens having different polarizations to simultaneously display the left and right

images. However, the higher cost of separate LCD screens, as well as the lack of availability of LCD screens with opposite polarization and otherwise identical characteristics, make multiple screen arrangements unsuitable for many applications. Furthermore, although stereoscopic effects could in principle also be obtained using a single screen on which the left and right eye images are simultaneously displayed, either side-by-side or top and bottom, in combination with one or more retarders to change the angle of polarization of one of the simultaneously-displayed images relative to the other, it is difficult in such arrangements to achieve left-and-right images of identical brightness, necessary for a true stereoscopic effect, because of attenuation in the retarder or retarders used to change the angle of polarization.

Despite the inherent polarization of the conventional LCD screens, the inventor has discovered that the most practical approach to achieving opposite polarization of the left and right images of a polarization-based stereoscopic system is to de-polarize the left and right LCD images so that they can be oppositely polarized, and furthermore that the de-polarization can be achieved using a screen overlay in the form of a lenticular or microprism sheet modified to diffuse light passing through the screen, the scattering caused by the diffusion having the effect of

de-polarizing the light. As a result, the above-described lenticular or microprism sheet overlay, which has a number of advantages unrelated to stereoscopic effects systems, turns out to be especially useful in the context of stereoscopic systems or devices of the type that rely on opposite polarization to distinguish left and right eye images.

SUMMARY OF THE INVENTION

It is accordingly a first objective of the invention to provide a simple, inexpensive, and yet versatile LCD overlay for selectively increasing an angle at which the LCD can be viewed or providing a privacy screening effect, and which further improves image quality by diffusing light passing through the overlay.

It is a second objective of the invention to provide an LCD overlay for selectively increasing an angle at which the LCD can be viewed, providing a privacy screening effect, and/or improving image quality, and which may be spaced apart from or in contact with the LCD screen.

It is a third objective of the invention to provide an LCD overlay for selectively increasing an angle at which

the LCD can be viewed, providing a privacy screening effect, and/or improving image quality, and which may be either permanently or removably secured to the LCD screen.

It is a fourth objective of the invention to provide a simple overlay for an LCD that has line doubling properties.

It is a fifth objective of the invention to provide a line doubler that can be used with a wide variety of image sources, including but not limited to LCDs.

It is a sixth objective of the invention to provide a simple overlay for an LCD that has de-polarizing properties.

It is a seventh objective of the invention to provide a de-polarized LCD assembly suitable for use as an image source in a stereoscopic effects system or device of the type described in U.S. Patent Application Ser. Nos. 09/538,731 and 09/729,079, or in any other polarization-based stereoscopic effects device or system.

It is a eighth objective of the invention to provide a stereoscopic effects system or device of the type in which the left and right images are simultaneously

displayed before polarization, which uses an LCD as the image source, and yet in which compensation for unequal attenuation of the left and right images is not required.

It is an ninth objective of the invention to provide an LCD which can be used in a polarization-based stereoscopic effects device or system, either as a single screen or as two identical screens, without having to alter the polarization of either screen, or compensate for differential attenuation as the relative polarization of the screens or screen portions is adjusted to differentiate the images.

It is a tenth objective of the invention to provide a liquid crystal display having a de-polarizing property, which can be used to selectively increase viewing angle or create a privacy screening effect, and yet which is low in cost and simple to manufacture.

It is an eleventh objective of the invention to provide a liquid crystal display having a line doubling property, which can be used to selectively increase viewing angle or create a privacy screening effect, and yet which is low in cost and simple to manufacture.

These objectives are achieved, in accordance with the principles of a preferred embodiment of the invention, by providing an overlay in the form of a lenticular or microprism sheet arranged to be positioned between a direct view type LCD screen and the viewer, and by modifying the overlay to provide diffusion effects.

Diffusion effects may be achieved through use of diffusion coatings, roughening or etching of surfaces of the overlay, and casting of materials with diffusion agents added to the material before solidification. Lenticular or microprism sheets with diffusion properties are disclosed, by way of example, in copending U.S. Patent Application Ser. No. 09/640,024, filed August 17, 2000.

In one preferred embodiment of the invention, a lenticular or microprism sheet is arranged to increase an angle at which an image on the LCD screen can be viewed, while at the same time diffusing the light to eliminate differences in contrast across the screen. In another embodiment of the invention, the lenticular sheet is arranged to provide a privacy screening effect by restricting viewing at certain angles that otherwise would be within the field of view.

In the case of a lenticular sheet, the individual lens elements may be one or two dimensional depending on the desired angle of view. In the case of one dimensional lens elements, the lens elements may be parallel and extend horizontally and/or vertically, or may form an arrangement of intersecting diagonals, while two dimensional lens elements are preferably arranged in a matrix. In the case of two-dimensional elements, the lens elements should be sufficiently fine to prevent Moire' effects, but otherwise dimensions of the lens elements is not considered to be critical.

In order to obtain a line doubling effect, the overlay needs to be arranged in lenticular columns having dimensions corresponding to the lines to be doubled and must be spaced from the LCD screen, or other images sources that might benefit from an apparent increase in resolution, such as a CRT, projection screen, and so forth. To compensate for the spacing the lenticular columns may be arranged on a grooved substrate or microprism sheet that also includes lens or prism elements on the side of the sheet facing the LCD.

The lenticular columns may be in the form of discrete one-dimensional lenticular elements formed in the grooves of a microprism sheet, or may be provided on a separate

sheet that can be attached to the microprism sheet or placed in proximity thereto. Furthermore, the lenticular elements or sheet may be made of a different material than the microprism sheet to take advantage of diffraction effects.

While diffusion is not critical to the line doubling effect in general, and while the line doubler may be used in connection with devices or systems other than direct-view LCDs or stereoscopic effects systems, when used in a polarizing stereoscopic effects system, diffusion is desirable to eliminate effects resulting from the inherent polarization of images displayed on an LCD.

An example of a stereoscopic effects system using the overlay of the invention includes an LCD image source on which left and right eye stereoscopic images are simultaneously displayed. Light from the image source is passed through the overlay in order to de-polarize the light and, optionally, achieve line-doubling, after which the left and right eye images are oppositely polarized, combined or interlaced by a further lenticular or microprism sheet, and viewed through oppositely polarized lenses.

Although especially useful in such a stereoscopic effects system, those skilled in the art will appreciate that the overlay of the invention may also be used in connection with other types of stereoscopic effects systems, including ones which do not require the viewing through polarizing lenses.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view showing an application of an LCD overlay constructed in accordance with the principles of the invention.

Fig. 2A is a schematic illustration, shown in cross-section, of the manner in which the overlay of the invention can be used to increase the angle of view, and also showing an example of a diffusion treatment for the overlay.

Figs. 2B and 2C are plan views of respective one and two dimensional lenticular sheet configurations which may be used in the overlay of the invention.

Fig. 3A is a schematic illustration, shown in cross-section, of the manner in which a lenticular sheet overlay can be used to achieve a privacy screening effect according

to principles of a variation of the preferred embodiment of the invention.

Fig. 3B is a schematic illustration, shown in cross-section, of an overlay corresponding to the overlay of Fig. 3A, but with a microprism sheet rather than a lenticular sheet.

Figs. 4A and 4B are schematic illustrations, also shown in cross-section, of line doublers constructed in accordance with the principles of a preferred embodiment of the invention.

Fig. 5 is a schematic illustration of a stereoscopic effects system employing the overlay of the invention for the purpose of achieving a de-polarizing effect.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As illustrated in Fig. 1, overlay 1 of the invention is designed to be used with a non-projection or direct-sight type LCD 2, for example the illustrated notebook computer screen. Of course, those skilled in the art will appreciate that overlay 1 is not limited to a particular type of LCD display, but rather may be applied to computer monitors, televisions, video game machines or devices, and

any other appliance or device having an LCD screen, and may be integrally manufactured with the screen or retrofit onto an existing screen, that it may conveniently be secured to the LCD screen by any convenient means, including adhesion between the plastic material of the overlay and the screen, mounting hardware, use of a frame surrounding the screen, and so forth, and that it may be permanently or removably secured, and in contact with or spaced from the screen. In the case of a removable overlay, the user can employ different versions of the overlay to exhibit different effects, for example by employing a privacy screening overlay in one situation, a contrast balancing overlay in another situation, and as a line-doubling, de-polarizing overlay in a situation involving stereoscopy.

As illustrated in Fig. 2A, the overlay 1 of the invention consists essentially of a sheet arranged to include a plurality of lens elements, which may be one dimensional elements 3, as illustrated in Fig. 2B, or two-dimensional elements 3', as illustrated in Fig. 2C. In the configuration of Fig. 2A, the lens elements are arranged to increase a viewing angle, according to elementary, well-known optical principles, by uniformly bending light rays 4A and 4B that originate from a single point to as to increase and angle between the respective rays and a line through the point that is normal to the plane of the sheet.

Unlike the conventional lenticular sheet overlays for direct-view LCDs disclosed in the above-cited U.S. Patent Nos. 5,555,476 and 5,745,199, however, the lenticular sheet overlay illustrated in Fig. 2A is further arranged to diffuse light passing through the sheet. In particular, the lenticular sheet overlay may be of conventional construction and materials, so long as it has optical properties that cause a light diffusion effect. Modification of surfaces to achieve light diffusion can be carried out by any of the methods described in the prior patents or patent applications cited above, including coating back, front, or both surfaces with a light diffusing material 5, casting irregularities into the surfaces, or modifying the surfaces by delustering, and/or chemical or laser etching. In the case of chemical or laser etching, surfaces may be caused to diffuse light by roughening, either by applying the chemical or directing the laser at the surface through an appropriate mask, or by etching the casting tool or die that forms the sheet. In addition, or alternatively, surfaces could originally cast a light diffusing finish, or a light diffusing compound could be dispersed into the material of the microprism sheet.

As discussed above, by adding diffusion properties to the sheet, the invention, in its broadest form, essentially

converts the direct-view system into a rear-projection system, minus the magnification, and thus any advantages such as contrast balancing and glare reduction obtained by using a lenticular sheet and diffuser in combination with a projection screen are also obtained in the context of a direct-view screen, and without the disadvantages of projection optics.

Instead of increasing the field-of-view of the direct-sight LCD screen, the invention can also be used for privacy screening purposes, achieved by preventing light rays 4C from exiting the sheet at certain angles while transmitting light rays 4A and 4B at different angles, as shown in Fig. 3A. The light blocking effect may be obtained by using an appropriate lens geometry, or by differentially treating surfaces of the sheet in a manner similar to that disclosed in copending U.S. Patent Application Ser. No. 09/481,942 (incorporated by reference herein), for example by increasing the diffusion effect along certain surfaces of the lens elements 3'' using delustering or etching, by selectively applying or varying the composition of a diffusion coating material, as it is applied to the different surfaces, or by varying the composition of the sheet material during formation.

In the variation shown in Fig. 3B, a microprism sheet 30 is substituted for the lenticular sheet of Fig. 3A. As illustrated, the microprism sheet 30 includes a privacy screen coating or treatment 60 of one surface of each prism element, and is made of a light diffusing material or compound. It will be appreciated by those skilled in the art that a corresponding microprism sheet could also be used in an overlay corresponding to the overlay illustrated in Fig. 3A.

In the embodiment shown in Fig. 4A, the LCD overlay serves as a line doubler. The lenticular sheet includes a microprism sheet or grooved substrate 7 on which is formed identical one-dimensional lens elements 8A and 8B, which may be made of the same or a different material than the grooved substrate 7. The substrate 7 is spaced from the LCD 2 by a distance d. Rays 9A and 9B are combined in lens 8A, rays 9B and 9C are combined in lens 8B, and so forth, effectively increasing the apparent resolution of an image displayed on LCD 2 by an amount proportional to the distance between the substrate and the LCD. Because of the spacing between the line doubler and the LCD, it may be desirable to incorporate additional lenticular or prism elements into the side of substrate 7 that faces LCD 2, or to add further microprism or lenticular sheets.

In the variation shown in Fig. 4B, the combined microprism/lenticular sheet is replaced by a microprism sheet 7 and a separate lenticular sheet including one-dimensional cylindrical type lens elements 8A' and 8B'. Again, the lens elements may be made of a different material than the microprism sheet, to take advantage of different indices of refraction, and may be adhered together or provided separately and placed in proximity.

Although especially suitable for use in connection with a direct view LCD of the type described above, those skilled in the art will appreciate that the basic principles of the line doublers shown in Figs. 4A and 4B, namely the use of cylindrical lenticular elements arranged on a grooved substrate and spaced from the image source, may be applied in a variety of contexts, including those in which diffusion effects are not required. Similar line doublers may, for example, be used in connection with conventional CRTs, projection screen televisions, and other image sources.

When arranged to exhibit light diffusing properties, the lenticular sheet of the embodiment illustrated in Figs. 4A and 4B may advantageously be used in a stereoscopic system or device of the type in which the left and right images are simultaneously displayed, either side-by-side or

in interlaced form, and therefore each have half the image lines that a conventional image would have. One such stereoscopic system is the system illustrated in Fig. 5, which is identical to the system disclosed in U.S. Patent Application Ser. Nos. 09/538,731 and 09/729,079 except for the addition of a LCD overlay having de-polarizing properties.

The overlay 10 may be identical to the overlays described above in connection with Figs. 2 and 3, *i.e.*, they preferably consist of a lenticular sheet modified to exhibit diffusion properties, the diffusion properties of the sheet serving to randomly change the polarization of light passing through the sheet, and therefore to de-polarize the light.

In addition to the overlay 10, the stereoscopic effects system of this embodiment of the invention includes a microprism sheet 11 arranged such that light from a first left or right eye image A is refracted by surfaces 12 and light from a complementary second right or left eye image B is refracted by surfaces 14 so as to exit the microprism sheet in parallel and thereby form a single interlaced image. Before combination, images A and B are conveniently polarized by polarizing filters or sheets 15,16 positioned between the de-polarizing overlay 10 and the microprism

sheet 11 so that, upon viewing through appropriately polarized lenses 9,10, the image A and image B components of the combined image will be separately viewed by the left and right eyes of a person, resulting in a stereoscopic image, *i.e.*, an image that appears to be three-dimensional.

Having thus described preferred embodiments of the invention in sufficient detail to enable those skilled in the art to make and use the invention, it will nevertheless be appreciated that numerous variations and modifications of the illustrated embodiment may be made without departing from the spirit of the invention. Accordingly, it is intended that the invention not be limited by the above description or accompanying drawings, but that it be defined solely in accordance with the appended claims.

What is claimed is:

1. An overlay for a non-projection direct view liquid crystal display (LCD) screen, comprising:

a sheet arranged to be secured to the LCD screen and positioned between the LCD screen and a viewer; and

a plurality of lens or prism elements formed in said sheet,

wherein said sheet is arranged to diffuse light emitted by said LCD screen.

2. An overlay as claimed in claim 1, wherein said lens or prism elements are arranged to increase a field-of-view of said LCD screen.

3. An overlay as claimed in claim 1, wherein said lens or prism elements are arranged to prevent said screen from being viewed at certain angles.

4. An overlay as claimed in claim 1, wherein said sheet includes a light-diffusing coating on at least one surface.

5. An overlay as claimed in claim 1, wherein said sheet includes irregularities cast into at least one surface.

6. An overlay as claimed in claim 1, wherein said sheet includes surfaces modified by delustering or etching.

7. An overlay as claimed in claim 1, wherein said lens elements are one-dimensional lens elements.

8. An overlay as claimed in claim 1, wherein said lens elements are two-dimensional lens elements.

9. An overlay as claimed in claim 1, wherein said sheet is removably secured to said LCD screen.

10. An overlay as claimed in claim 1, wherein said sheet is spaced apart from said LCD screen.

11. An overlay as claimed in claim 10, wherein said sheet includes one-dimensional lens elements arranged to serve as line doublers.

12. An overlay as claimed in claim 1, wherein said sheet de-polarizes light passing through the sheet.

13. A line doubler, comprising:

a substrate having a plurality of v-shaped grooves, said substrate being arranged to be positioned between an

image source and a viewer and to be positioned a predetermined distance from the image source; and

a plurality of one-dimensional lenticular elements aligned with said grooves to achieve a line doubling effect.

14. A line doubler as claimed in claim 13, wherein said substrate is a microprism sheet and said lenticular elements are discrete lens elements situated in said grooves.

15. A line doubler as claimed in claim 13, wherein said substrate is a microprism sheet and said lenticular elements are formed in a separate lenticular sheet situated adjacent the microprism sheet.

16. A line doubler as claimed in claim 15, wherein said lenticular sheet is adhered to said microprism sheet.

17. A line doubler as claimed in claim 13, wherein said microprism sheet and lenticular elements are made of different materials.

18. A line doubler as claimed in claim 13, wherein said image source is an LCD screen.

19. A stereoscopic effects system, comprising:

an LCD arranged to simultaneously display left and right eye images;

a de-polarizing sheet positioned in front of said LCD for de-polarizing light emitted by the LCD;

polarizers for separately polarizing said left and right eye images; and

a second sheet arranged to interlace said left and right eye images.

20. A stereoscopic effects system as claimed in claim 19, wherein said second sheet is a microprism sheet.

21. A stereoscopic effects system as claimed in claim 19, wherein said de-polarizing sheet includes a substrate arranged to be secured to the LCD screen; and

a plurality of lens or prism elements formed in said substrate,

wherein said de-polarizing sheet is arranged to de-polarize said images by polarizing light emitted by said LCD screen.

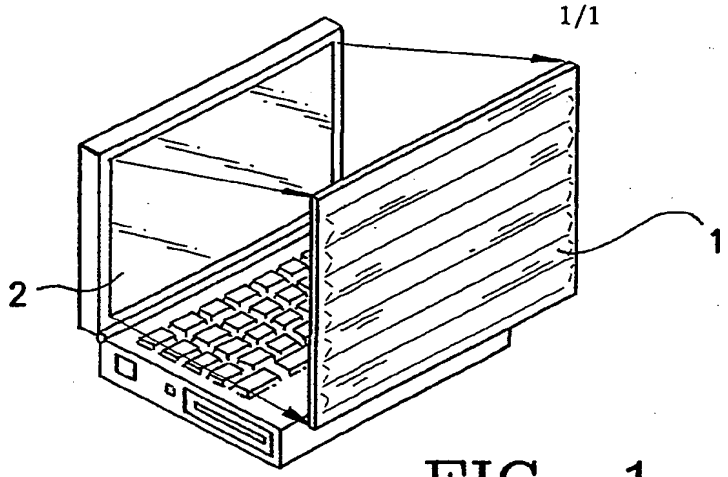

FIG. 1

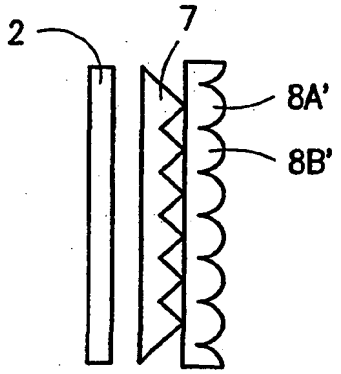

FIG. 4B

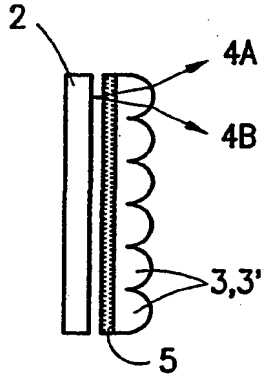

FIG. 2A

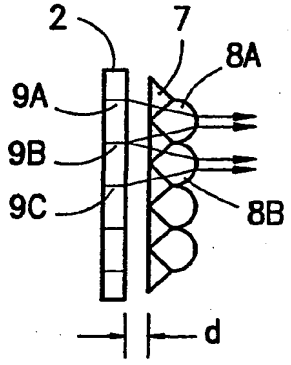

FIG. 4A

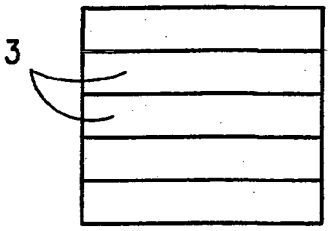

FIG. 2B

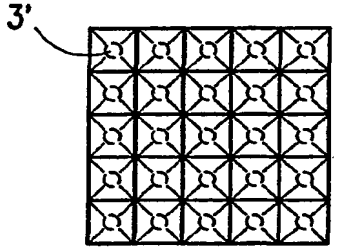

FIG.2C

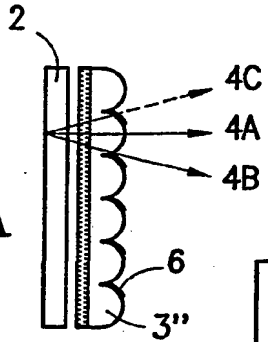

FIG. 3A

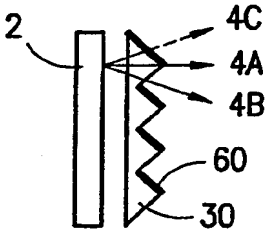

FIG. 3B

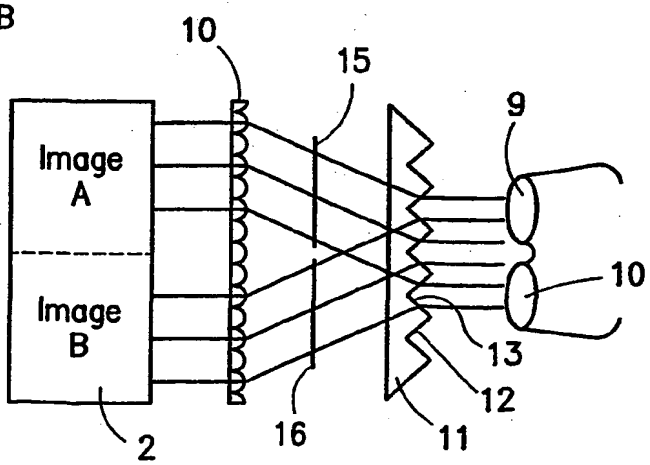

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US02/01246

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : G02B 27/22, 27/26, 27/10
US CL : 359/463, 465, 619, 620, 621
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 359/462, 463, 465, 619, 620, 621, 622, 623, 624, 625, 626; 348/57, 58, 59

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS
search terms: lenticular, microprism, stereoscopic, polarization, depolarizers.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, 5,886,760 A [UEDA et al] 23 March 1999 (23.03.99), see the entire document.	1-12
X	US, 3,959,580 A [CHOCOL et al] 25 May, 1976 (25.05.76), see the entire reference.	13-18
Y	US, 4,588,259 A [SHEIMAN] 13 May 1986 (13.05.86) see the entire document.	19-21
Y	US, 5,721,603 A [De VAAN et al] 24 February 1998 (24.02.98), see the entire document.	19-21

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 05 APRIL 2002	Date of mailing of the international search report 18 APR 2002
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer AUDREY CHANG Telephone No. (703) [illegible] Deborah Perry-Leeper Paralegal Specialist Technology Center 2800

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